SCIENCE.

FRIDAY, MARCH 1, 1895.

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*ON DR. WILLIAM TOWNSEND PORTER'S INVESTIGATION OF THE GROWTH OF THE SCHOOL CHILDREN OF ST. LOUIS.**

DR. Porter's investigations on the growth of the school children of St. Louis claim particular attention, as the author opens a number of new problems and proposes new methods of inquiry. His conclusions are far-reaching and have a close relation to the method of treatment of a number of questions. It is the importance of these investigations, which are based on very extensive material, which induces me to subject the author's methods to an examination.

Dr. Porter's scheme of measurements is based largely upon that used by Dr. H. P. Bowditch in his investigations in Boston, and on the one which I used in the collection of data in Worcester, Mass. To these the measurements of girth of chest and of strength of grasp are added. It must be regretted that Dr. Porter determined the age of the child at its nearest birthday,

*1. The Physical Basis of Precocity and Dullness. (Transactions of the Academy of Science of St. Louis, Vol. VI., No. 7, March 23, 1893.)

2. The Relation between the Growth of Children and their Deviation from the Physical Type of their Sex and Age. (Ibid., Vol. VI., No. 10, November 14, 1893.)

3. Untersuchungen der Schulkinder in Bezug auf die physischen Grundlagen ihrer geistigen Entwicklung. (Verh. d. Berliner Gesellschaft für anthropologie, 1893, pp. 337–354.)

4. The Growth of St. Louis Children. (Transactions of the Academy of Science of St. Louis, Vol. VI., No. 12, April 14, 1894, pp. 263–380; republished in Quarterly Publications of the American Statistical Association, N. S., No. 24, Vol. III., December, 1893, pp. 577–587.)

5. The Growth of St. Louis Children. (Ibid., Nos. 25, 26, Vol. IV., March–June, 1894, pp. 28–34.)

while heretofore all investigators determined the age in full years. There exists, therefore, a difference of half a year between the period of Dr. Porter's tables and all others which makes a comparison difficult.

Dr. Porter bases all his discussions on the assumption that all series of observations of children of any given age are probability curves, and he illustrates this point by a detailed discussion of the observations on stature of eight-year-old girls. In connection with this subject he discusses the meaning of the probable deviation, of the mean, and of the average value of the series. Although he employs both the mean and average values, he evidently inclines toward the use of the former. I will not dwell at length upon the fact that whenever the curve is really a probability curve the average is a better value than the mean, because it is more accurate, nor on the other fact that the mean deviation gives a more constant value than the probable deviation, and is therefore the better value, as both considerations have little practical bearing, although I consider them of importance from a theoretical point of view.

It may be granted for a moment that the curves are probability curves. Then there remain two objections to Dr. Porter's values. The one is that the difference in numbers of individuals observed for each year is not taken into consideration. This difference in numbers has the effect that the average age of all individuals whose nearest age is six years will be a little more than six years. These corrections amount to more than 3% of the annual growth, during the first and last years to even more. It affects the annual rate of growth of stature to the amount of several millimeters, the weight to the amount of half a pound.

Furthermore, Dr. Porter makes a linear interpolation for determining the mean, while the general curve ought to be taken into consideration. The determination of the 50% point of a series ought to be based on the values found at two points, at least, on each side. The same may be said of the interpolation for all the other percentile grades. The corrections made necessary by these two causes are not great, but sufficient to make all the millimeters and tenths of kilograms inaccurate.

A more important objection is based on the fact that the observed curves are *not* probability curves. In examining Dr. Porter's curve for stature of girls of 8 years of age (paper No. 4, p. 286), it will be seen that in the first part of the table the differences between theory and observation are all positive, while in the second part they are, with one exception, all negative. When the curves of stature, weight, span of arms, height sitting, girth of chest for girls from 12 to 15 years of age, and for boys from 14 to 18 years of age are consulted it will appear that the asymmetry is still more marked. Dr. Porter himself quotes at length Dr. Bowditch's remarks on this asymmetry (Ibid., p. 298), and calls attention to the difference between mean and average. These constantly occurring differences and their regular distribution are the very best proof that the curves under consideration are not probability curves. If this is the case, neither the average, nor the mean, nor the most frequent value represent the type of the age to which the curve refers. This can be determined only by a detailed examination of the causes of the asymmetries.

I have stated at a former time (Science, Vol. XIX., May 6, May 20, 1892) what I believe to be the cause of this asymmetry, and I will revert to this subject after the discussion of one of Dr. Porter's most fundamental deductions.

He concludes, from his data, that the basis of dullness is deficient physical development; that the basis of precocity is an unusually favorable physical development.

His method has been to compare the measurements of all children of a certain age attending various grades of schools. He found that those in the lower grades were inferior in their measurements to those attending the higher grades. He expresses this result in the following language (No. 1, p. 168): "Precocious children are heavier, and dull children lighter, than the mean child of the same age. This establishes a basis of precocity and dullness." I believe that the method of investigating this point is not free of objections. It would, indeed, be a serious accusation against the teachers of St. Louis if they should entirely disregard the effects of physical development in grading their pupils. However crudely this may be done, it is certainly done to a limited extent. Sickly children who stay out of school for a great portion of the term will lag behind; vigorous ones will advance more rapidly. Be this the case or not, the fact remains that children who are physically more vigorous accomplish a greater amount of mental work. But I do not believe that Dr. Porter's wording of the phenomenon conveys the correct interpretation. I should prefer to call the less favorably developed grade of children retarded, not dull; and these terms are by no means equivalent, as a retarded child may develop and become quite bright. In fact, an investigation which I had carried on in Toronto with the same object in view, but according to a different method, gives just the reverse result. The data were compiled by Dr. G. M. West, who found that the children pronounced by the teacher as bright were less favorably developed than those called dull by their teachers. Furthermore, I do not believe it is correct to say that the facts found by Dr. Porter establish a basis of precocity and dullness, but only that precocious children are at the same time better developed physically; that is to say, the interesting facts presented by Dr. Porter prove only that children of the same age who are found in higher grades are more advanced in their general development than those who are found in lower grades. Dr. Porter has shown that mental and physical growth are correlated, or depend upon common causes; not that mental development depends upon physical growth.

This brings me back to the question of the cause of the asymmetries of the observed curves. According to the above interpretation of Dr. Porter's results (which is merely a statement of the observed facts), we must expect to find children of a certain age to be on different stages of development. Some will stand on the point corresponding exactly to the age, while others deviate from it. This was the assumption which I made in the paper quoted above, when trying to explain the asymmetries of the curves, and I consider Dr. Porter's observations a very strong argument in favor of my theory, which is briefly as follows:

When we consider children of a certain age we may say that they will not all be on the same stage of development. Some will have reached a point just corresponding to their age, while others will be a little behind, and still others in advance of their age. Consequently the values of their measurements will not exactly correspond to those of their age. We may assume that the difference between their stage of development and that belonging to their exact age is due to accidental causes, so that just as many will be less developed as further developed than the average child of a particular age. Or, there will be as many children on a stage of development corresponding to that of their age plus a certain length of time as corresponding to that of their age minus a certain length of time.

The number of children who have a certain amount of deviation in time may be assumed to be arranged in a probability curve, so that the average of all the chil-

dren will be exactly on the stage of development belonging to their age.

At a period when the rate of growth is decreasing rapidly, those children whose growth is retarded will be further remote from the value belonging to their age than those whose growth is accelerated. As the number of children above and below the average of development are equal, those with retarded growth will have a greater influence upon the average measurement than those whose growth is accelerated, therefore the average value of the measurement of all the children of a certain age will be lower than the typical value, when the rate of growth is decreasing; higher than the typical value when the rate of growth is increasing. This shows that the averages and means of such curves have no meaning as types. I have shown in the place quoted above, how the typical values can be computed, and also that for stature they differ from the average up to the amount of 17 mm.

These considerations also show clearly that the curves must be asymmetrical. Supposing we consider the weights of girls of thirteen years of age, the individuals composing this group will consist of the following elements: girls on their normal stage whose weight is that of the group considered, advanced girls, and retarded girls. In each of these groups which are represented in the total group in varying numbers, the weights of the individuals are probably distributed according to the laws of chance, or according to the distribution of weights in the adult population. What, however, will be the general distribution? As the rate of increase of weight is decreasing, there will be crowding in those parts of the curves which represent the girls in an advanced stage of development, and this must cause an asymmetry of the resultant general curve, which will depend upon the composition of the series. This asymmetry does actually exist at the period when the theory demands it, and this coincidence of theory and observation is the best argument in favor of the opinion that advance and retardation of development are general and do not refer to any single measurement.

Futhermore, the increase in variability until the time when growth begins to decrease, and its subsequent decrease, are entirely in accord with this theory. I have given a mathematical proof of this phenomenon in the paper quoted above (Science, May, 1892). Dr. Porter has called attention to the same phenomenon in his paper of November, 1893, but I believe his formulation is not sufficiently general, nor does he give an interpretation of the phenomenon which may be explained as follows: The probability of a child not being in the stage of development corresponding to its age follows the laws of chance. With increasing age the mean deviation from the normal type must increase. Assuming that at the age of four years, .5 year represents the mean deviation, then a certain number of children will be in the stage of development corresponding to 3.5 and 4.5 years. At the age of sixteen years the mean deviation will probably be one year, and just as many children would be on the stages of fifteen and seventeen years as there were of the four-year old children on the stages of 3.5 and 4.5 years. The absolute amount of growth (in girls) from fifteen to seventeen years is less than from 3.5 to 4.5, so that for this reason a decrease in variability must be found at the time when the rate of growth begins to decrease. On the other hand, the difference between individuals which will finally become tall or short, increases with the increase of growth, so that the combined effect of these counteracting causes will be a maximum of variability at the period preceding puberty. Dr. Porter's formulation of the phenomenon (No. 2, p.

247) that "the physiological difference between the individual children in an anthropometric series and the physical type of the series is directly related to the quickness of growth" does not quite cover the phenomenon.

It will be seen from these arguments that the very natural supposition that some children develop more slowly than others is in accord with all the observed facts. It was necessary to prove this in some detail, because the further interpretations made by Dr. Porter largely hinge upon this point.

These conclusions are based on the assumption that "the type at a certain deviation from the mean of an age will show the same degree of deviation from the mean at any subsequent age; for example, a type boy in the 75 percentile grade at age 6 will throughout his growth be heavier than 75 per cent. of boys of his own age." (No. 4. p. 293.) This assumption which I have criticised on a former occasion (SCIENCE, Dec. 23, 1892, p. 351), is most decidedly incorrect, and with it fall all the conclusions in regard to the growth of tall children and short children.

We know a number of facts which show plainly that the assumption is incorrect. It has been shown in Dr. Bowditch's tables that Irish children are shorter than American children. If the position of the American child is expressed in percentile grades of the whole Boston series, and that of the Irish child in the same manner, it will be seen at once that they diverge more and more with increasing age. Pagliani's measurements of Italian children and my own of Indian tribes of different statures bring out the same point still more strongly.

I think the error underlying the assumption that the average children retain their percentile rank can be shown best in the following manner: We know by means of observations the distribution of measurements for certain ages. If the assumption is made that the same children remain on the average in the same percentile grade a certain very complex law of growth follows. We may invert this reasoning by saying: Only if the assumption of a certain very complex law of growth is made can the same children remain in the same percentile grade. For any different law of growth they would change from one grade to another. There is no inherent probability in this law; on the contrary, it was quite unexpected and surprising when first promulgated. As a matter of fact, three factors condition the rate of growth: hereditary influences, the preceding life history of the individual and the average conditions during the period under consideration, and it is quite unlikely that these factors should always be found to stand in such a relation as to result in general stability of percentile grades.

As the facts disprove this assumption, and as the cause of the asymmetries remains entirely obscure under it, while they can be fully explained in all their details by the theory advanced before, I cannot acknowledge that the conclusions reached regarding the growth of tall and short children are correct.

On pp. 339–348 of his fourth paper Dr. Porter makes a valuable suggestion regarding the practical application of measurements to the determination of the stage of development of individuals. His proposal is to compute the distribution of weight, chest, girth and others correlated to various heights. Then all children are under the suspicion of being abnormally developed who differ much from the standard values. Dr. Porter assumes the narrow limits of the probable deviation as the limits of normal variability. It may be a question where these limits ought to be drawn, but there can be no doubt that this method is much better than the one applied in our gymnasia, namely, that the individual is expected to

be in all his measurements on the same percentile grade. This latter method is based on a quite erroneous theory of the proportions of the body. Dr. Porter's method is also better than that based on single measurements, as it points out abnormal proportions, not simply abnormal size. It is necessary, however, to bear in mind the one restriction that many measurements are not closely correlated with stature, but have different correlations. This is the case with girth of chest, strength of squeeze and many others. Therefore their correlation to stature will not give more satisfactory results than the study of the single measurements alone. It will certainly be of great use to school hygiene to subject all children whose proportions are abnormal to a medical examination, but it will not be possible to determine by means of the measurements what individuals are retarded in growth and what are advanced, as Dr. Porter suggests, except in very exceptional cases. The correlation between any two measurements is so slight that a great many cases which are normal for one year are also quite normal for the preceding and following years at least. This is also shown by the fact which is apparently so contradictory, that children of a certain height are the heavier the older they are (according to Bowditch), but that also children of a certain weight are the taller the older they are.

Finally, I must say a word in regard to Dr. Porter's objection to the combination of measurements taken in different cities. It is, of course, true that the results in various cities depend upon the composition of the population and its geographical and social surroundings. If we knew all these factors and their influences it would be necessary to sub-divide the series of each city into numerous divisions. As we do not know the exact influence of these factors, we must endeavor to take as our basis a general curve, including as many individuals as possible of the same population but under a diversity of conditions and compare the curves determined by certain factors with them. It is, therefore, perfectly correct to compute the growth of American children from data collected in various cities, provided each city is given its proper weight according to the number of children measured. The more cities and villages are included in such a combination, the more nearly we shall get the curve representing the growth of the American child. By comparing the general curve with the ones obtained in different cities we can investigate the causes which produce the difference between the individual curves and the general curve. We know that nationality, occupation, social status have a considerable influence. I have found that first-born children exceed later-born children in size. The effect of all these causes can be studied by comparing the individuals representing each group of factors with the general population.

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*LABORATORY TEACHING OF LARGE CLASSES IN BOTANY.**

The great increase in the size of the classes in Elementary Botany during late years in Harvard College has forced their teachers to the development of some system for their efficient and economical management in the Laboratory. Under the guidance of Professor Goodale there has been worked out the plan upon which are based the recommendations made in this paper; indeed, what I have to say is little more than a description of the system in use there during the last year I was connected with it, *i. e.*, 1892–'93. My observations are, therefore, based not upon theory alone, but upon the results of trial and selection.

*Read before the American Society of Naturalists, Baltimore, Dec. 28, 1894.